Thermal imaging of the outer surface of the Laboratory for engines and vehicles at the Faculty of mechanical engineering and naval architecture

Doris Županić, Antonio Bolarić, Mia Stančić, Denis Piljek, Bojan Jurinjak

ABSTRACT

Laboratory for engines and vehicles at the Faculty of mechanical engineering and naval architecture has been recently renovated by installing thermal insulation on the outer surface of the three facades of the building: south, east and north facade.

Goal of the project was to record required thermograms of the renovated facades in a proper time of a day and make comparison with old thermograms created before renovation.

After analysis and comparison of the thermograms we have full insight in the new object condition. One can see now if there are any heat leaks.

By observing the thermograms recorded before and after of the insulation placement one can deduce that even though there are some flaws that could be remediated, thermal insulation has contributed to the overall heat losses. There is a significant improvement in terms of reducing temperature distribution on the outer surface of facade.

Introduction

Thermography has become an indispensable method for the determination of defects in construction, power engineering, and mechanical engineering or as a method for supervising the installation and detection of possible defects. In addition to these technical areas thermography has found its application in: medicine, veterinary medicine, military applications, restoring works of art, etc. IR thermography is a method of measuring temperature and its distribution on the surface of the body. Thermographic cameras observed radiation in the infrared band of the electromagnetic spectrum and on the basis that give results thermographic measurement called thermograms. Infrared radiation emitted by all of the bodies depending on their temperature, therefore, this method is based on measuring the intensity of infrared radiation from the observed surface. As the amount of radiation increases with temperature, thermography allows you to see the changes in temperature or the temperature distribution on the surface of the observed object. This gives an insight about different states of such surfaces.

IC thermography in buildings

In building construction, IR thermography is used for testing the quality of building insulation, determining places with increased humidity, air permeability, moisture detection and roof insulation failure, determination of thermal bridges, estimates of heat loss of the building, revealing a condensation and dew, detection of structural elements under plaster. Infrared thermography is an extremely useful method for visualizing heat loss through construction elements when researching and improving the energy efficiency of buildings.

Using thermographic images of elements of the building structure can be in them, non-aggressive method to identify disadvantages related to the thermal characteristics. The ability of thermographic devices (IR cameras) to quickly and efficiently register the small temperature differences make it suitable for the determination of discontinuity temperature distribution on the surface of the building envelope. Thermographic scanning of buildings, and the level of existing to locate construction deficiencies and to direct interventions on the reconstruction of the optimal improvement of the energy efficiency of buildings.

Object of observing

Table 1. General information of the measuring object

Object of measurement :	Laboratory for engines and vehicles, FSB
Time and date of measurement:	4.2.2014.; 11 h i 30 min
Coordinates of object:	+45° 47′ 44.19′, +15° 58′ 23.97′′
Address of object:	Miramarska road, 10000 Zagreb, Croatia
Subject of measurement:	The external envelope of the building
The envelope before works:	Concrete walls without thermal insulation and glass doors and windows with associated metal frames (without thermal insulation)
The envelope after work:	Concrete walls with thermal insulation and glass doors and windows with associated metal frames (without thermal insulation)
Emission factor reinforced concrete of envelope:	e = 0,90
Emission factor enameled metal frame without shine :	e = 0,88
Outside temperature:	To= 0,5 °C
Temperature of south facade:	Tamb= - 2,2 °C
Temperature of east facade:	Tamb= - 1,7 °C
Temperature of north facade:	Tamb= -0,6 °C

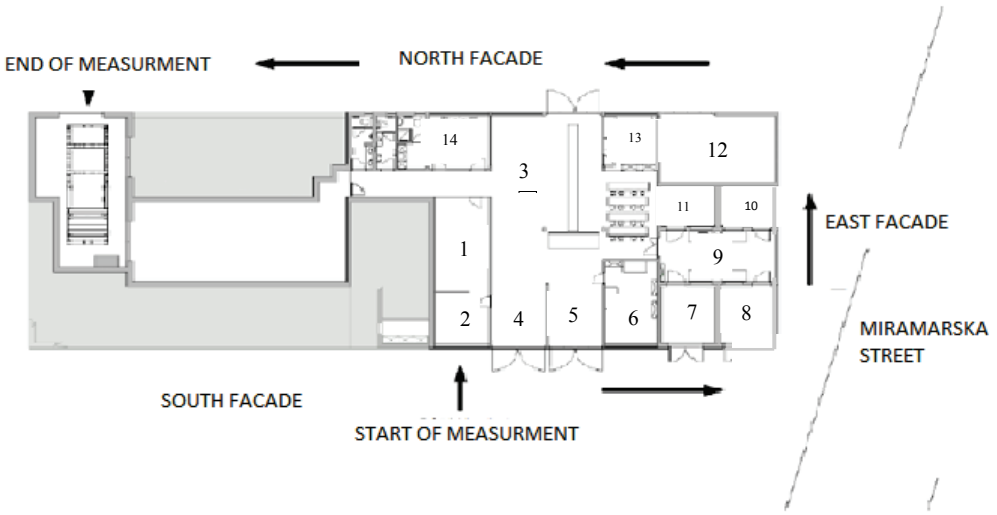

Fig. 1. Ground plan of the building of the Laboratory for engines and vehicles

Table 2. List of rooms and associated internal temperature

Room	Room temp.[°C]	Details
1	22,7	- internal room without openings
2	-	- closed radiator; temperature slightly lower than room 1
3	22,4	- main room
4	22,4	- part of main room
5	22,4	- part of main room
6	23,5	- radiator of external wall
7	9,4	- no radiators (big gap on the door)
8	19,1	- radiator on east wall (big gap on the door)
9	19,0	- two radiators on east wall (big gap through room 8)
10	21,5	- radiator on east wall
11	9,2	- no radiators, room in building proceed
12	21,2	- non heated room
13	22,7	- heated room
14	23,7	- bigger temperature because room is full of people

Thermal insulation

Thermal insulation on the Laboratory for engines and vehicles at the Faculty of mechanical engineering and naval architecture is consisted of:

- 80 mm of rockwool
- smooth concrete mass
- 1-2 mm of silicate plaster.

Thermal insulation was placed on every part of the 3 facades including the edges of windows and doors. Steel doors were not subjected to placement of thermal insulation. Images below show the installation of thermal insulation as well as the final building condition.

Fig. 2. South facade works a)

Fig. 3. South facade works b)

Fig. 4. South facade final view

Thermal imaging equipment

Fluke Ti25 infrared thermal imaging camera was used for recording thermograms and SmartView Fluke™ Application was used for quantitative analysis. Table below shows the camera most important specifications.

Table 3. Fluke Ti25 specifications

Field of view (FOV):	23 ° horizontal x 17 ° vertical
Focus:	Manual
Lowest focal distance:	ID lens: 15 cm (ca. 6 in), VIS lens: 46 cm (ca. 18in)
Temperature sensitivity: (temperature resolution -NETD)	≤ 0.1 °C at 30 °C (100 mK)
Lowest span (Auto/Manual):	5 °C/ 2.5 °C
Temperature range:	- 20 °C to + 350 °C (- 4 °F to + 662 °F), 2 ranges
Accuracy:	± 2 °C or 2% (higher value)

The aim and the purpose of the thermal imaging

Goal of the project was to record required thermograms of the three renovated facades in a proper time of a day and make comparison with old thermograms created before renovation. After analysis and comparison of the thermograms we should have a full insight in the new object condition. One can see now if there are any heat leaks.

Comparison of the thermal imaging before and after placing the thermal insulation

Following images show thermal imaging comparison of 3 facades of the Laboratory for engines and vehicles at the Faculty of mechanical engineering and naval architecture before and after placing the thermal insulation. Along with brief comments, positive and negative influences of placing thermal insulation will be shown.

Images on the left side represent thermal imaging before placing the thermal insulation whereas images on the right side those after performed works. It should be noted that the glass areas as well as metal surfaces will not be considered (window glass areas and door metal surfaces represent areas of extremely high temperature).

South façade

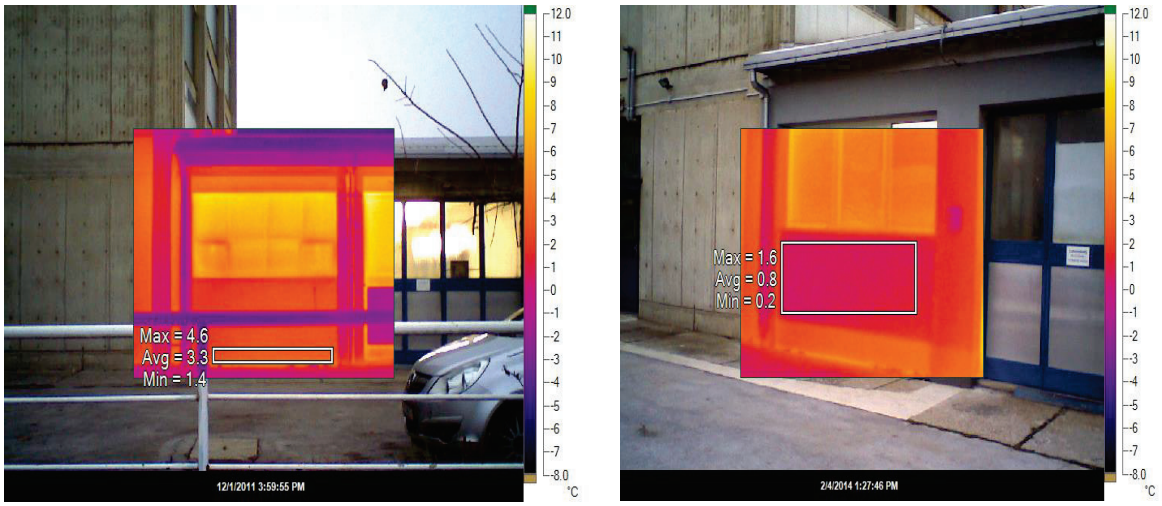

Fig. 5. South façade thermal imaging comparison

Comparing these two thermal images one can see stark contrast between facade surface temperatures. Before placing the thermal insulation, average surface temperature was 3, 3 °C, whereas after performed works 0, 8 °C representing vast heat losses reduction.

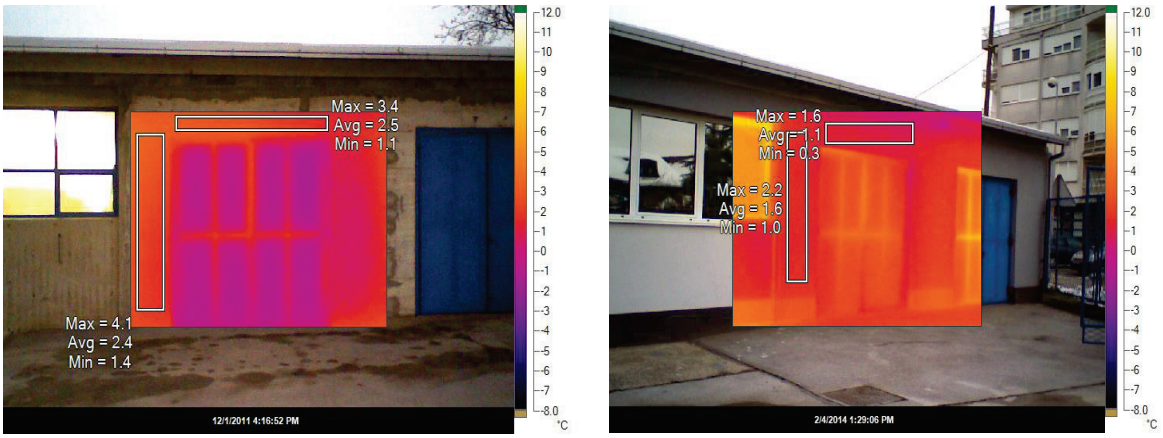

Fig. 6. South façade thermal imaging comparison

Apart from difference between surface temperatures of selected areas, one can see that placed thermal insulation provides equally good results at the bearing walls and as well as above the doors.

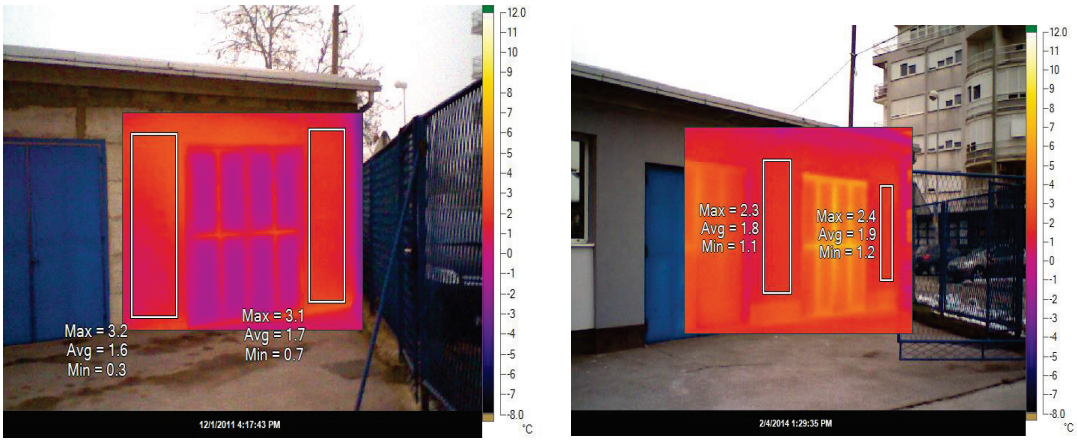

Fig. 7. South façade thermal imaging comparison

Fig. 7. shows unexpected situation. It is obvious that the average surface temperature after placing the thermal insulation is higher than before. One of the reasons of such situation is the radiator which generates heat (before placing thermal insulation this room was not used and therefore the radiator did not generate heat). Regardless of whether the place is heated or not, here we can see inefficiency of placing the thermal insulation.

East façade

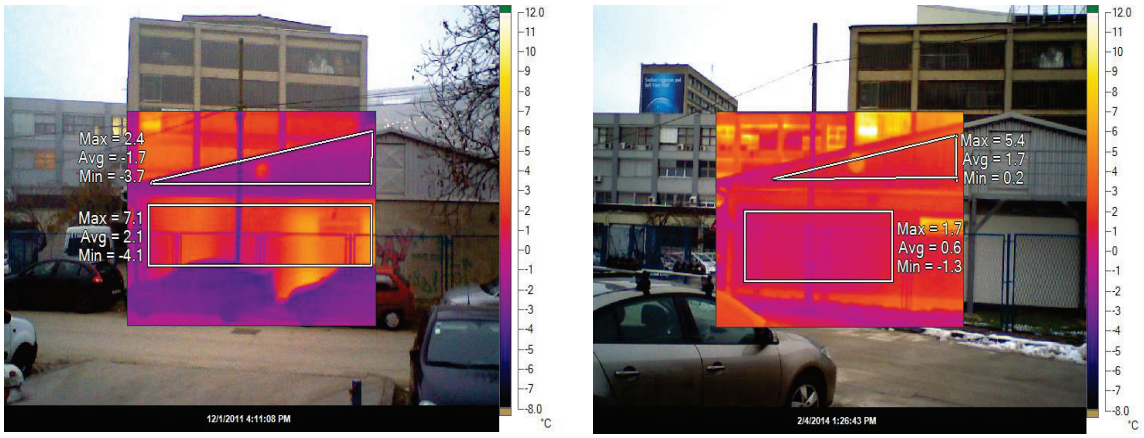

Fig. 8. East façade thermal imaging comparison

First, if we look at lower part of the facade, we can see reduced heat losses, especially if we look average surface temperature which amounted 2, 1 °C before, and 0, 6 °C after placing thermal insulation. Another indication showing improved situation is solving interior heat losses problems caused by radiators.

Now, if we look the upper part, we can observe that the average surface temperature on the left thermal image is 2 °C lower than the one on the right. Reason for this is the fact that before placing thermal insulation loft space was not heated. Ventilation shaft continues to represent thermal loss. During taking thermal images there were some obstacles like: parked cars, trees, fence and these had to be taken into account.

North façade

North façade best demonstrates the efficiency of placing the thermal insulation of the façade. Thus, figures 9., 10. and 11. show the average temperature difference before and after placing the thermal insulation somewhere between 3,3 °C and 3.4 °C.

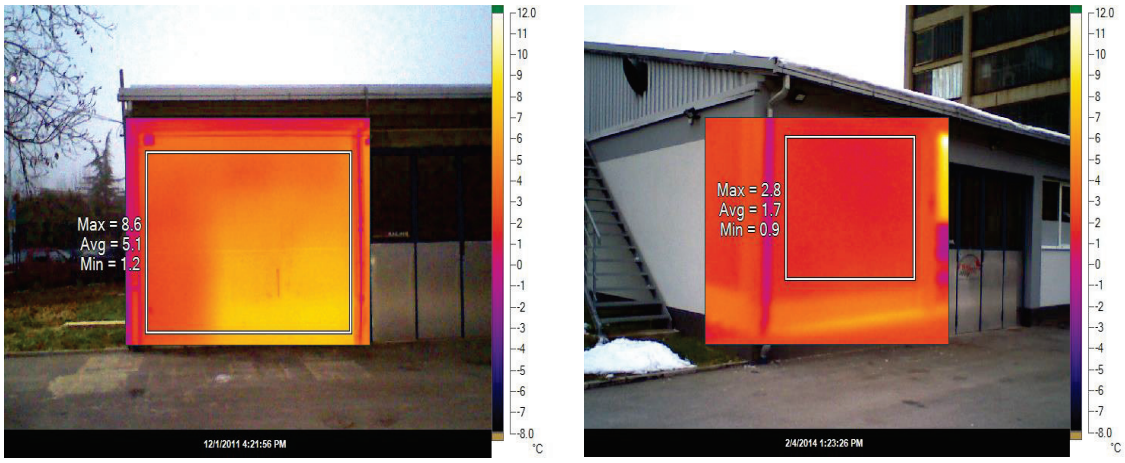

Fig. 9. North façade thermal imaging comparison

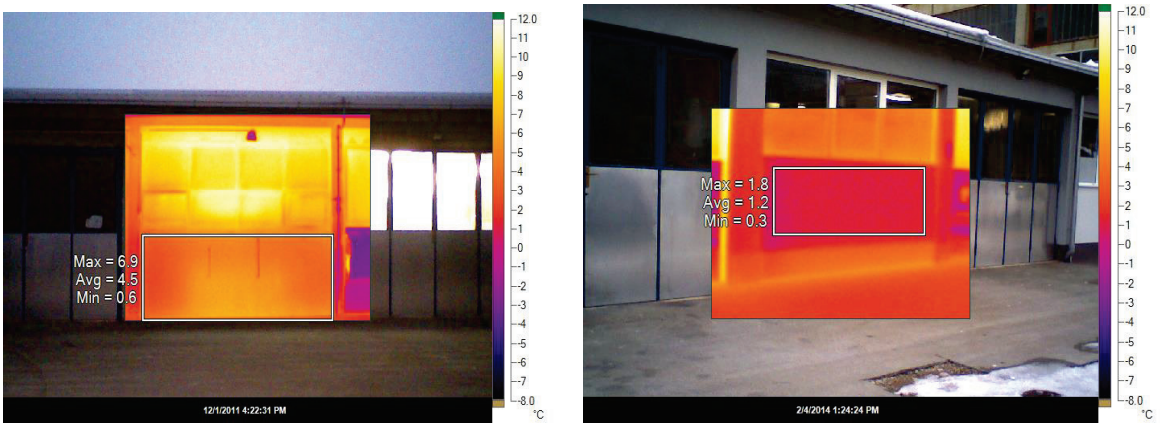

Fig. 10. North façade thermal imaging comparison

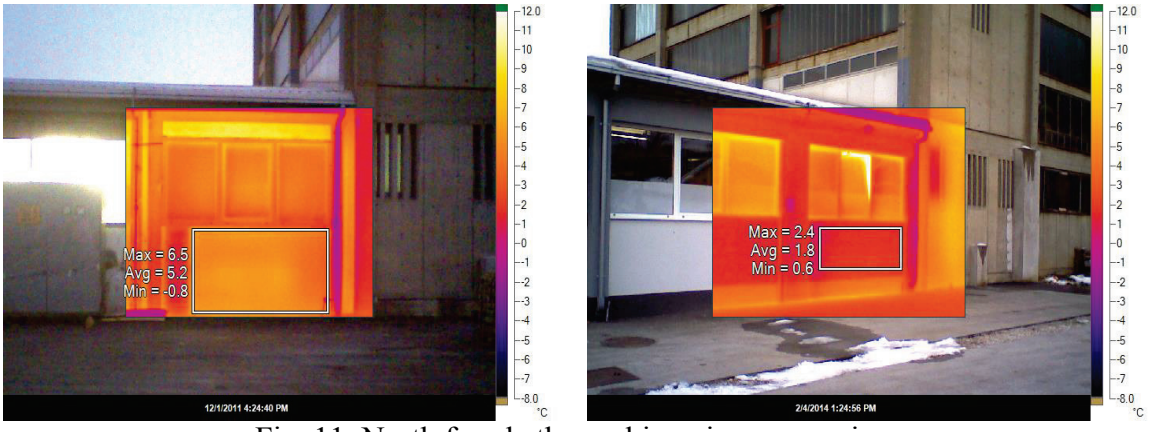

Fig. 11. North façade thermal imaging comparison

Conclusion

By observing the thermograms recorded before and after of the insulation placement one can deduce that even though there are some flaws that could be remediated, thermal insulation has contributed to the overall heat losses. There is a significant improvement in terms of reducing temperature distribution on the outer surface of facade.